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Near-infrared photonic energy penetration: can infrared phototherapy effectively reach the human brain?

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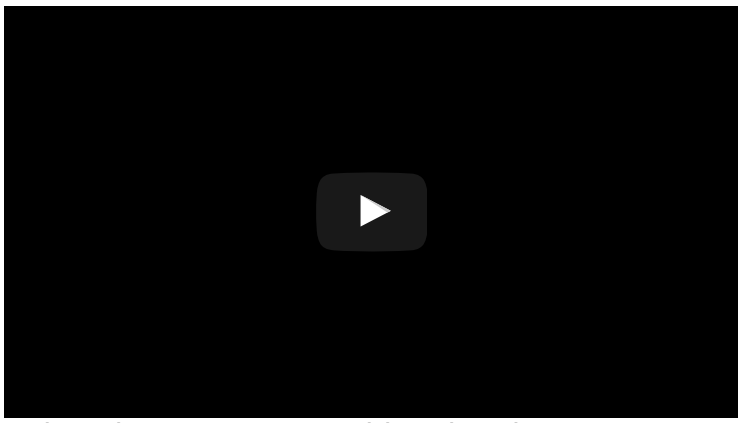
Abstract: Traumatic brain injury (TBI) is a growing health concern effecting civilians and military personnel. Research has yielded a better understanding of the pathophysiology of TBI, but effective treatments have not been forthcoming. Near-infrared light (NIR) has shown promise in animal models of both TBI and stroke. Yet, it remains unclear if sufficient photonic energy can be delivered to the human brain to yield a beneficial effect. This paper reviews the pathophysiology of TBI and elaborates the physiological effects of NIR in the context of this pathophysiology. Pertinent aspects of the physical properties of NIR, particularly in regards to its interactions with tissue, provide the background for understanding this critical issue of light penetration through tissue. Our recent tissue studies demonstrate no penetration of low level NIR energy through 2 mm of skin or 3 cm of skull and brain. However, at 10–15 W, 0.45%–2.90% of 810 nm light penetrated 3 cm of tissue. A 15 W 810 nm device (continuous or non-pulsed) NIR delivered 2.9% of the surface power density. Pulsing at 10 Hz reduced the dose of light delivered to the surface by 50%, but 2.4% of the surface energy reached the depth of 3 cm. Approximately 1.22% of the energy of 980 nm light at 10–15 W penetrated to 3 cm. These data are reviewed in the context of the literature on low-power NIR penetration, wherein less than half of 1% of the surface energy could reach a depth of 1 cm. NIR in the power range of 10–15 W at 810 and 980 nm can provide fluence within the range shown to be biologically beneficial at 3 cm depth. A companion paper reviews the clinical data on the treatment of patients with chronic TBI in the context of the current literature.



Video abstract presented by Theodore A Henderson and Larry D Morries.

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